GEOLOGY OF GUAYAQUIL, ECUADOR, SOUTH AMERICA

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by

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INTRODUCTION

In January and February 1921, the first-named author visited the city of Guayaquil and made a short geological examination of the hills in the northern part of the city. A few specimens of the rocks were brought to New York where thin sections were made and put through a petrographic and palaeontological examination. This paper is an outgrowth of these studies and is offered only as a small contribution to our knowledge of the geological conditions in this region.

The hills mentioned rise to an elevation of 300 feet above the Guayas River, the tidal stream on the right bank of which the city is situated, and form a part of a ridge which west of Guayaquil is known under the names, Cordillera de Chongón and Cordillera de Colonche. This ridge reaches the Pacific Ocean about 85 miles west of the city and according to Wolf [1]attains a maximum elevation of between 2000 and 2600 feet above the sea. It is broken at Guayaquil by the Guayas River but east of the river it is represented by five isolated hills which die out a short distance farther east into the low plains that reach to the base of the Andes Mountains.

That portion of the ridge in the northern part of the city is called "Cerro de Santa Ana" and on its summit is the city's water reservoir. Just west of Guayaquil, in the slopes of the ridge are quarries which have furnished paving and building stones for many years.

The city itself lies for the most part on that flat flood plain of the river, but in the hills above mentioned, sedimentary rocks are everywhere exposed under conditions of folding, faulting and apparent lack of fossils which make their stratigraphical relations and age difficult of determination. In general, however, one can readily distinguish two clearly differentiated kinds of rocks, – the first composed of sandstones and shales, the second, of cherty rocks and limestones.

The only published account of these rocks known to us is by Theodor Wolf [2]who has described them in terms of which the following is a partial translation:

"Beds of limestone, siliceous limestone, siliceous slate, silica, quartzite, yellow and green glauconitic sandstone and shale alternate in thin layers in a very remarkable manner. The limestone is rarely pure enough to burn for lime. It is almost always impregnated with silica which increases to the point where the limestone becomes a siliceous shale containing little lime. Most of the limestone is of white or yellowish color but there are varieties of siliceous limestone nearly black in color due to impregnation with bitumen. The beds of sandstone which alternate with the calcareous and siliceous strata are nearly always of dark greenish, yellow color. It appears that the sandstones predominate in the lower beds and the limestones in the upper. Stratification in many places is completely destroyed. The beds are also so steeply inclined and, in many places, so violently contorted and faulted that it is difficult to determine their strike.

Fossils have been found in only one locality, viz. in paving blocks in the streets of Guayaquil which contain remains of *Inoceramus* characteristic of the Cretaceous in other parts of the world. The greater part of these fossils is so crushed that it is difficult to recognize them. Professor Geinitz [3]distinguished *Inoceramus latus Sowerby* among these however. I have searched in vain in all the quarries near Guayaquil for the place from which these paving stones came but could never find the bed or indeed fossils of any kind."

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[1] Theodor Wolf, Geografía y Geología del Ecuador, Leipzig, 1892

[2] Theodor Wolf, Geognotische Mittheilungen aus Ecuador, Neues Jahrbuch für Mineralogie, 1874, pp. 377-398

[3] Wolf gives his authority for his statement on the fossils: Geinitz, Das Elbthalgebirge, 11, page 45, Table XIII, figs. 4 and 5. The only reference we have been able to find of this name is Hans Bruno Geinitz, Das Elbthalgebirge in Sachsen, Part 2, 11, vol. 20, Palaeontographica-Beiträge zur Naturgeschichte der Vorwelt, Cassel, 1872-1875, but in this there is no account of any fossils from Guayaquil. There is a description of the *Inoceramus* mentioned by Wolf but without any locality mentioned.

With the above account in mind, we also made a diligent search for fossils but with the same results as Wolf obtained. We were, however, rewarded by finding in the thin sections, fossil forms which are visible only under the microscope and these were identified for this paper.

Samples' description

The character of the cherty limestones of Guayaquil is fairly well shown by the following description of three typical samples:

- **Sample E-1** is a nearly white, dense rock, of micro-fine, almost amorphous, texture whose original structure was organic and which was subsequently modified somewhat by replacement and silicification. The essential primary constituents are microscopic organic forms, both carbonate and silica-bearing, including radiolaria and foraminifera. The introduced substance is chiefly silica. The rock was originally made up almost wholly of microorganisms, probably with both siliceous and calcareous shells and the rock still maintains this mixed composition. The matrix is largely carbonate but the principal fossil spots are siliceous, the two constituents being about equally abundant. It therefore is neither a simple limestone nor a true chert, but its origin and character are certain. Such a rock would probably be of simple silica or chert composition in some places and of almost straight carbonate composition in others with all sorts of gradation between. Its origin is organic and it is classified as a cherty infusorial and foraminiferal rock.

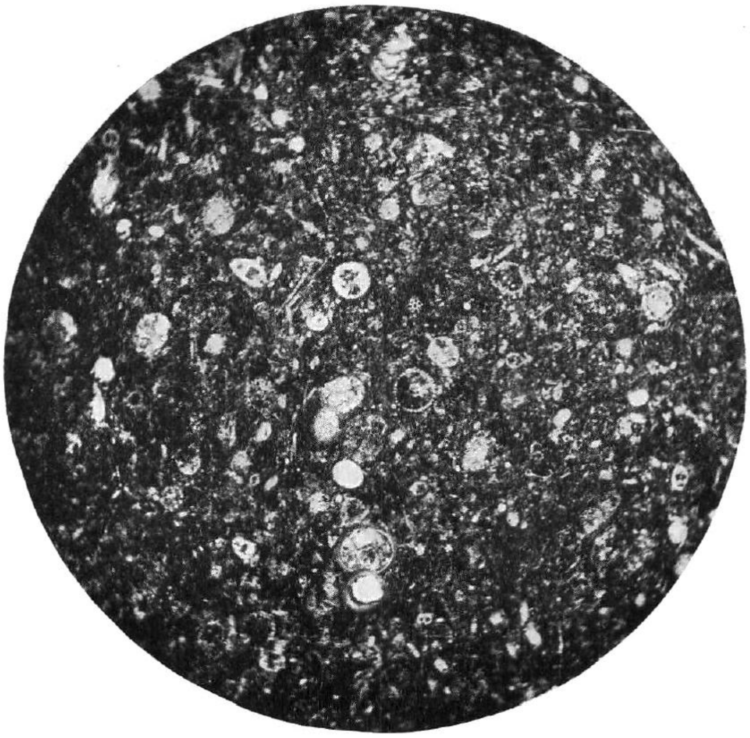

FIG. 1 – Photomicrograph of sample E-1 taken in plain light, magnification of about 30 diameters showing the micro-organisms that make up this rock.

- **Sample E-2** also is a nearly white, dense rock of microfine texture whose original structure was organic and which by secondary processes has been indurated. The primary essential minerals are microscopic forms including radiolaria and foraminifera, furnishing both carbonate and silica. It is of exactly the same origin as E-1 with the same intermixture of siliceous and calcareous constituents. It is perhaps a little patchier in the distribution of these constituents than E-1.

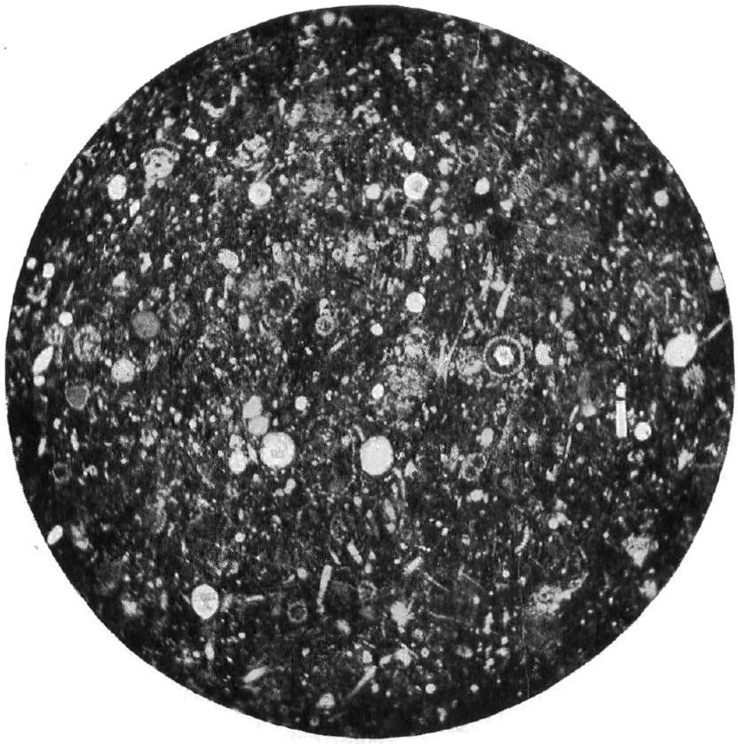

FIG. 2 – Photomicrograph of sample E-2 taken in plain light, magnification of about 30 diameters showing the fine structure and the microorganism makeup of the rock.

- **Sample E-3** is a gray-colored rock of sedimentary appearance whose texture varies from fine to medium. Its original structure was chiefly clastic but it has now a secondary veined structure. The primary essential minerals are quartz and feldspar fragments, carbonate and fossil forms of considerable variety, including foraminifera. This rock differs from E-1 and E-2 in that it carries a large amount of angular fragmental mineral material. Most of these are practically fresh feldspar fragments and this leads to the belief that the fragments are not of ordinary weathering or disintegration origin but may be of ash or volcanic origin instead. There are other mineral grains of much less prominence lending support to the same interpretation. The groundmass or matrix is chiefly carbonate carrying an abundance of minute fossil forms, the variety of which is somewhat greater than in E-1 and E-2. The rock is in part organic, therefore, and in part clastic but it doubtless is a member of the same series of sedimentary accumulations represented by E-1 and E-2 except that the local conditions were somewhat different at the time this one was deposited. It is therefore classified as an ash bearing foraminiferal lime rock.

FIG. 3 – Photomicrograph of sample E-3 taken in plain light, magnification of about 30 diameters showing the mixed composition of the rock. The angular clear grains are chiefly fragments of feldspar and quartz. The matrix is an aggregate of carbonate and finer fragments and the large regular structure is of organic origin.

These three samples illustrate the range from a cherty infusorial rock with both carbonate and chert as prominent constituents, to a carbonate rock with micro-organic and fresh mineral fragments in abundance. It is evident that they are essentially accumulations of microorganisms in which radiolaria and foraminifera dominate and that they form extensive accumulations of mixed siliceous and carbonate composition. With these beds, however, are associated clastic materials in varying proportions and probably of considerable range of composition.

Fossils' identification

The photomicrographs show plainly the presence of many forms which Dr. H. N. Coryell of Columbia University was able to identify as follows:

E-1 (fig. 1.) *Orbulina universa*
Ostracoda
Globigerina bulloides

E-2 (fig. 2.) *Orbulina universa*

E-3 (fig. 3.) *Lituola* (*Haptophragma*) *irregularis*
Textularia
Gastropoda
Rotalia

Dr. Coryell writes: “These forms are consistent for Cretaceous age, some of them being equally appropriate for the Eocene. On the whole we judge them to be Cretaceous.”

The fauna consists of single-to-many-chambered lime secreting foraminifera and single-chambered silica secreting radiolaria. Animals of this nature are pelagic and move about near the surface of the sea in large colonies. The siliceous radiolaria are found in both deep and shallow waters; the calcareous foraminifera and siliceous sponges are inhabitants of shallow seas.

CONCLUSIONS

We know of no other occurrence of cherts in Ecuador except in the Santa Elena peninsula about 85 miles west of Guayaquil. These have been described in a previous paper[4]. In all essential respects the Guayaquil and Santa Elena cherts are petrographically similar. They have the same general origin and are in essentially the same present condition and have gone through the same sort of life history. The organic forms are similar at least in major characters. We are as much impressed by the similarity of origin, history and condition as by anything else. They are alike in all these points even to the presence in some of the beds of angular fragments of fresh, clastic minerals thought to be ash, and in the matter also of change in quality of vein-filling or healing of the breccia in different stages of deformation.

The calcareous specimens of the Guayaquil and Santa Elena districts contain a foraminiferal fauna of identical genera and related species indicating that the beds from which these specimens were collected are of about the same age, and that they were deposited under very similar conditions. Judging from the microscopic forms in the two localities, it is concluded that they are all consistent for Cretaceous age.

In a forthcoming paper, on the geology of the Amazon Plain east of the Andes in Ecuador[5], there will be described the discovery of a widespread series of Upper Cretaceous limestones lying nearly horizontal and undisturbed at the base of the Andes Mountains. These are highly impregnated with bitumen and collections of many fossil forms leave no doubt as to their Upper Cretaceous age. This section is the reference point for Ecuadorian stratigraphy and it would appear reasonable to conclude that the Santa Elena cherts and the Guayaquil rocks are representatives of these limestones west of the Andes. The bitumen content, apart from the fossiliferous evidence, is strikingly noticeable.

New York City and Berkeley, California.

[4] Joseph H. Sinclair and Charles P. Berkey, Cherts and Igneous Rocks of the Santa Elena Oilfield, Ecuador. Trans. Amer. Inst. Mining and Metallurgical Engineers, Canadian Meeting, Montreal, August, 1923, 17 pages.

[5] The geographic features of this region have been recently described by Joseph H. Sinclair and Theron Wasson in a paper entitled: Explorations in Eastern Ecuador, The Geographical Review (American Geographical Society) New York, April, 1923, pages 190-210.

Location Map